EFFECT OF HEAT STRESS ON BODY COMPOSITION OF EGYPTIAN BUFFALO-CALVES

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Abstract

This study was carried out at the Experimental Farm of Animal Physiology Research Lab, Faculty of Agriculture, Cairo University, during the summer season of 2004. The objective was to assess the relevant physiological responses and growth performance of Egyptian buffalo-calves to artificial constant severe heat stress (40°C, 87.5 % RH, lab A), comfort (25 °C and 64.5% RH, lab B). Eight buffalo-calves were used (4 in each lab), their age and live body weight were 6 months and about 119 kg, respectively. Animals in both labs were assessed under their conditions for two times (trial 1 and trial 2), each one continued for one month, between them animals spent fifteen days outdoors. Then, they were slaughtered.

Heat stress caused reduction in the weight of the visceral organs. Fast BW and empty BW were decreased. Heat stress caused decrease in the length of small and large intestines and appendix. Fat % in the lean meat was reduced due to heat stress in both longissimus dorsi and semitendinosus muscles.

INTRODUCTION

The general vital condition in the animal body is acquired by its integrated physiological activities leading to continuous interactions of physico-chemical arrangements. These interactions maintain the basic specific internal conditions of the body, i.e., temperature along with hydrostatic and osmotic pressure integrated with acid-base balance. These internal body conditions are continuously affected and interacting with the external environmental conditions, i.e., thermal, feed and water status, as well as biotic circumstances (Ragab *et. al.,* 1966).

The most important reaction to heat exposure is the depression in feed consumption. High environmental temperature stimulates the peripheral thermal receptors to transmit suppressive nerve impulses to the appetite centre in the hypothalamus causing the decrease in feed consumption. Thus, fewer substrates become available for enzymatic activities, hormone synthesis and heat production which minimize thermal load (Kamal, 1975). Exposure to severe heat suppresses the production by the hypothalamic centre of hormone releasing factors causing a decrease in pituitary hormonal secretion (Johnson, 1974).

Kamal and Johnson (1971) attributed these to the contradictory responses of live BW under heat stress to the interaction between tissue destruction and water retention. The authors found that stressed calves lost 10.6 kg body fat and gained 0.6 kg lean mass solids with a net total body solids of 10 kg in three days. This loss was replaced by extra body water retained during these three days without a significant change in body weight.

Many authors studied carcass composition and muscle area during different ages (Ragab *et. al.*, 1966, Calub *et. al.,*1971, Tahir *et. al.*, 1985 and Fooda, 1996). The present work was executed to assess the relevant physiological responses of buffalo-calves to artificial constant severe heat stress (40°C), comfort (25°C) and outdoors natural climatic conditions as affecting their growth pattern and carcass parameters.

MATERIALS AND METHODS

This study was carried out at the Experimental Farm of the Animal Physiology Research Lab, Animal, Faculty of Agriculture, Cairo University. The experimental procedures and data collection were executed during the summer season of 2004.

Eight buffalo-calves (*Bubalus bubalis*) were available for this study (4 in each lab), from Mehalet Mousa Experimental Farm, Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture, Egypt. On the beginning of the experiment, the age of each calf was 6 months and its live body weight (BW) ranged between 118.0 - 119.3 kg. All animals appeared normally healthy.

This work was carried under two constant thermal conditions (CTC); heat stress (HS), 40°C, lab A and CS, 25°C, lab B. Two trials, each of one month in both labs were interrupted by 15 days (outdoors natural climatic condition) .

Feeding commercial concentrate ration was offered in surplus amount daily to determine the free - well fed intake (FI). The roughage feeds, wheat straw and Berseem (Trifolium alexandrinum) hay were also delivered in surplus. The concentrate ration was a starter during the first month of experimentation (6-7 months), then, followed by a growth concentrate till the end of experimental work at the 9th month of age. The chemical compositions of the dry matter of feeds (DM%) are shown in Table 1.

Lab A was equipped by 4 heaters controlled by highly sensitive digital thermostat alongside ceiling and suction fans. Thus, the ambient temperature (AT) in this lab was fixed and maintained exactly at 40°C, the relative humidity (RH) was 87.3 – 87.7 % and the temperature-humidity indexes (THI) was 101.2±0.1–100.0±0.1 at the 1st trial and 100.8±0.1-100.7±0.1 at the 2nd trial. Lab (B) was equipped by air conditioner and ceiling fan to maintain the AT at 25°C, the RH was 61.3 – 67.9 % and the THI was 74.0±0.3–75.0±0.6 at the 1st trial and 75.8±0.5-76.7±0.2 at the 2nd trial.

Table 1. Summit chemical compositions (%) of the dry matter in feeds.

	Crude protein	Crude fat	Crude fiber	Ash	NFE*
Starter. conc.	21.40±0.09	7.26±0.01	11.45±0.09	11.70±0.09	48.19±0.50
Growth conc.	14.40±0.03	6.80±0.01	16.53±0.09	14.70±0.06	47.57±0.45
Wheat straw	2.00±0.001	5.50±0.009	45.20±0.30	9.93±0.02	37.37±0.35
Berseem hay	12.95±0.01	3.88±0.008	32.30±0.20	12.00±0.03	38.87±0.35

* NFE: Nitrogen free extract, Conc.: concentrate

The calves were slaughtered at the end of the experiment after fasting for 19 hours, to determine the weights of the body components, live body weight, empty body weight, non-visceral offals (head, feet and hide) and visceral offals (heart, lungs, trachea, rumen, reticulum, omasum, abomasum, small and large intestines, liver, kidney, spleen, gall bladder and adipose tissue on abomasum).

The lengths (cm) of small, large intestines and appendix were determined. Weight of longissimus dorsi muscle (LD, kg) ribs 10, 11 and 12 and Semitendinosus (ST) were recorded. The ribs cut were dissected to find out weights of bone, muscle and fat depots.

Chemical analysis of minced flesh (muscle) samples from LD and ST were analysed according to A. O. A. C. (1990) to determine moisture, crude fat, crude protein and ash to perceive the metabolic course of tissue buildup.

Relevant statistical analysis of data was carried out applying the Statistical Analysis System (SAS, 2000).

Growth coefficient (b) for the weights of the components (Y, kg) of the empty body weight using empty body weight (X, kg) as independent variable was estimated according to the Huxley's function :

$$Y = a X^b$$

Y : weight (kg) of the part – component,

a : intercept,

X : weight (kg) of the whole – component,

b : regression coefficient of Y on X.

RESULTS AND DISCUSSION

Body composition in response to the thermal conditions

a. Body weight and general composition

Table 2 presents fast body weight (FBW), empty body weight (EBW) and carcass and offals as percentage of EBW. Under heat stress (HS), the weight (kg) of FBW and EBW were significantly decreased compared with the weight under comfort state (CS) by 60.3 (36 %) and 57.00 kg (38 %), respectively. The carcass and offals percentages of EBW showed non-significant differences between the two groups (A and B).

Table 2. FBW, EBW and their respective proximate components of the groups A and B at the end of the experiment, as affected by two CTC (Mean ± SE).

Items	(A) 40°C	(B) 25°C
FBW (kg)	$106.75{\pm}5.57^{b}$	$167.00{\pm}4.18^{a}$
EBW (kg)	$93.06{\pm}5.93^{b}$	$150.06{\pm}0.89^{a}$
<u>As percentage of EBW:</u>		
Carcass	$57.53{\pm}0.31^{a}$	$55.63{\pm}0.75^{a}$
Offals	$42.47{\pm}0.31^{a}$	$44.37{\pm}0.75^{a}$

In the same row means with different superscripts are significantly different (P<0.05).

b. Weight of the non-visceral offals

Weights of the non-visceral offals of the two groups (A and B) are shown in Table 3. The weights were significantly less in the HS (group A) compared with those in the CS (group B).

Table 3. Weight (kg) of the non-visceral offals of the groups A and B as affected by two CTC (Mean ± SE).

Items	(A) 40°C	(B) 25°C
Head	$7.38{\pm}0.31^{b}$	$10.63{\pm}0.13^{a}$
Feet	$4.25{\pm}0.14^{b}$	$6.00{\pm}0.20^{a}$
Hide	$8.13{\pm}0.72^{b}$	$14.75{\pm}0.95^{a}$
Total	$19.75{\pm}7.05^{b}$	$31.38{\pm}1.00^{a}$

In the same row means with different superscripts are significantly different (P<0.05).

c. Weight of the visceral offals

Weights of the visceral offals of the two group calves (A and B) are shown in Table 4. Under HS, the weights of all offals were significantly less in the HS calves, except the abomasums (AB), while, they increased during comfort case.

d. Length of small, large intestines and appendix

Heat stress caused decrease in the lengths of small and large intestines, as well as in appendix by 15, 32 and 18 %, respectively. (Table 5).

Table 4. Weight (kg) of the visceral offals of the groups A and B as affected by two CTC (Mean ± SE).

Items	(A) 40°C	(B) 25°C
Heart	0.51±0.01 [b]	0.84±0.06 [a]
Lung and trachea	1.88±0.24 [b]	2.88±0.13 [a]
Rumen	2.50±0.05 [b]	4.75±0.14 [a]
Reticulum	0.35±0.05 [b]	0.64±0.06 [a]
Omasum	0.75±0.09 [b]	1.95±0.19 [a]
Abomasum	1.09±0.12 [a]	0.94±0.19 [a]
Intestines (small and large)	3.25±0.048 [b]	5.13±0.13 [a]
Liver	1.75±0.10 [b]	2.56±0.07 [a]
Kidneys	0.53±0.02 [b]	0.85±0.06 [a]
Spleen	0.21±0.01 [b]	0.30±0.00 [a]
Abomasum fat	-	0.98±0.21
Total	12.8±0.86 [b]	21.75±0.44 [a]

In the same row means with different superscripts are significantly different (P<0.05).

Table 5. Length of small and large intestines and appendix of the groups A and B as affected by two CTC (Mean ± SE).

Items	(A) 40°C	(B) 25°C
Small intestines (m)	13.75±0.85 [a]	16.25±1.33 [a]
Large intestines (m)	5.13±0.24 [b]	7.50±0.46 [a]
Appendix (cm)	31.75±2.72 [a]	38.75±2.50 [a]

In the same row means with different superscripts are significantly different (P<0.05).

e. Growth coefficient

Growth coefficient (b) for the weight of the components (Y, kg) of the EBW (X, kg) is presented in Table 6, where, b value < 1 is the early growing, b value > 1 is the late growing and b value = 1 is the normal growing. The grow of visceral, non-visceral offals and carcass weight under HSC are less than them under CS. On the other hand the growing of the small and large intestines was early under HS compared with CS.

f. Meat quality as affected by the thermal conditions

1. Area of longissimus dorsi muscle

Area of LD decreased by 17 % by the effect of HS (Table 7).

2. Ribs (10, 11, 12) cut components

Heat stress decreased significantly total muscle and fat weights without any effect on bone weight (Table 8).

Table 6. Growth coefficients (b) for the weights of the components (Y, kg) related to the empty body weight.

Items	(A) 40°C	(B) 25°C
Carcass weight	0.94	1.11
Total offals weight	0.64	0.91
Non-visceral offals :		
Head	0.18	-0.43
Feet	-0.07	0.97
Hide	0.83	2.44
Total	0.39	1.14
Visceral offals :		
Heart	-0.21	0.71
Lungs and trachea	1.66	1.70
Rumen	0.50	0.59
Reticulum	1.59	3.09
Omasum	-1.04	3.09
Abomasum	0.75	-6.47
Small and Large intestines	2.21	-0.89
Liver	0.72	0.41
Gall bladder	-1.09	0.0
Kidneys	-0.47	1.95
Spleen	0.50	0.0
Total	1.02	0.56

Table 7. Sectional area (cm²) of LD of the groups A and B as affected by two CT (Mean ± SE).

(A) 40°C	(B) 25°C
15.9±0.98 [a]	19.2±2.72 [a]

No Significant difference (P<0.05).

Table 8. Weights (kg) of the ribs 10, 11 & 12 cut and their meat components of groups A and B as affected by exposure to two CTC (Mean ± SE).

Items	(A) 40°C	(B) 25°C
Total weight	1.34±0.09 [b]	1.98±0.15 [a]
Muscle weight	0.81±0.10 [b]	1.41±0.70 [a]
Fat weight	0.10±0.00 [b]	0.13±0.00 [a]
Bone weight	0.43±0.03 [a]	0.44±0.09 [a]

In the same row means with different superscripts are significantly different (P<0.05).

3. Chemical analysis for meat components

The percentages of chemical components of meat in LD and ST are shown in Table 9. The percentages of dry matter (protein, fat and ash) were decreased by HS. The water content was decreased under HS compared with CS case for LD and ST.

Table 9. Chemical components (%) of lean meat in L.D. and ST of the groups A and B as affected by two CTC (Mean ± SE).

Items	EM		ST	
	(A) 40°C	(B) 25°C	(A) 40°C	(B) 25°C
Dry matter :-				
Protein	22.9±2.70 [a]	23.2±2.30 [a]	19.1±2.40 [a]	20.5±0.96 [a]
Fat	3.9±1.12 [b]	10.5±0.59 [a]	2.3±0.61 [b]	5.9±0.18 [a]
Ash	2.2±0.88 [a]	1.1±1.80 [b]	2.1±1.80 [a]	2.9±0.90 [a]
Moisture	71.0±1.11 [a]	65.2±1.63 [b]	76.5±1.70 [a]	70.7±0.89 [b]

In the same row means with different superscripts are significantly different ($P<0.05$).

CONCLUSION

Heat stress caused reduction in the weight of the visceral organs as compared to those under comfort conditions, except those of the abomasums. The reduction was greater in rumeno-reticular part and omasum, which coincided with the reduction in FI, particularly RI. As suggested above HS induced adaptive reconstitution of body components which are clear from the growth coefficients of visceral organ weights to the EBW. The respiratory system (lung and trachea) showed positive relation with the body weight, almost equal in both groups (1.66 and 1.70). This could be concomitant with the body surface rather than the body weight. The coefficients of the heart and kidney are negative (-0.21 and -1.09, respectively) in the heat stressed group. This means that growth of these organs is faster than or even resistant to the drop in body weight.

The effect of HS on the meat chemical components is evident. The sectional area of LD was more by 20 % in the comfort group (B) over that in stressed group (A).

We can summarize, that the heat stress decreased visceral and non visceral weights that led to lower meat production.

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تأثير الإجهاد الحراري علي مكونات الجسم في عجول الجاموس المصري

فايزة إبراهيم عمران[1] ، جمال عاشور[2] ، محمد محمود الشافعي[2] ، محمد محمد يوسف[1] ، منصور محمد أحمد[2]

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أجريت هذه الدراسة بالمزرعة التجريبية بمعمل فسيولوجيا الحيوان – كلية الزراعة جامعة القاهرة خلال موسم صيف عام 2004. و كان الهدف من هذه الدراسة الحالية هو تقدير الإستجابة الفسيولوجية الخاصة بعجول الجاموس للإجهاد الحرارى الشديد و الثابت (40 درجة مئوية) ، و الظروف المريحة (25 درجة مئوية) و كذلك الظروف المناخية الطبيعية و تأثير ذلك على مظاهر النمو..

وأستخدم فى هذة الدراسة ثمانية عجول جاموسى (4 في كل معمل) عمر كل منها ستة شهور ووزنه 118 الى 119.3 كجم وتم قياس إستجابة العجول تحت نوعين من الظرو ف الحرارية هما الإجهاد الحرارى داخل معمل (أ) حيث كانت درجة الحرارة ثابتة و مستمرة (40 درجة مئوية) بينما كانت الرطوبة النسبية 87.5 ٪ و كذلك داخل معمل (ب) تحت الظروف المثلي من درجة الحرارة (25 درجة مئوية) و الرطوبة النسبية (65.5 ٪) و أجريت تجربتان كل منهما لمدة شهر داخل هذة المعامل يفصل بينهما فترة 15 يوماً عرضت فيها الحيوانات الى الظروف المناخية الطبيعية خارج المعمل.

و يمكن تلخيص أهم نتائج هذة التجربة فيما يلى:

- ادي الاجهاد الحراري الي انخفاض وزن الاعضاء الحشوية بالمقارنة مع الظروف المثلي ماعدا اوزان المعدة الحقيقية (الانفحة).
- انخفضت اوزان الجسم الفارغ والصائم بحوالي 36 ٪ و38 ٪ تحت ظروف الاجهاد الحراري عن الظروف المثلي.
- ادي الاجهاد الحراري الي انخفاض في اطوال الامعاء الدقيقة والغليظة والزائدة الاعورية بحوالي 15 و 32 و 18 ٪ علي التوالي .
- اظهر الجهاز التنفسي علاقة موجبة مع وزن الجسم وكان متشابهاً في كل تا المجموعتين.
- كانت معاملات النمو لكل من القلب والكليتين سالبة (- 0.21 و-1.09) في العجول المجهدة حراريا.
- العضلة الظهرية وقطعيات الضلوع كانت اكبر بحوالي 20 ٪ و 50 ٪ مع زيادة في نسبة اللحم بحوالي 74 ٪ تحت الظروف الطبيعية عن نسبها تحت ظروف الاجهاد الحراري.
- انخفضت نسبة الدهن في اللحم نتيجة الاجهاد الحراري في كل من العضلة الظهرية وعضلة الفخذ.

وعليه نستنتج أن الإجهاد الحراري أدي إلي إنخفاض أوزان الأعضاء الحشوية والغير حشوية وأدي ذلك إلي إنخفاض نسبة التصافي والتشافي وبالتالي نقص في إنتاج اللحم.